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Bluetooth Mesh

What is it, what can it be used for and how can I take advantage

Introduction

Bluetooth Mesh is the latest extension of Bluetooth technology. It significantly extends the capabilities and potential uses of Bluetooth. In particular, it adds capabilities particularly suited to smart building and home automation applications. However, it is not limited to this, and there are many other applications areas where a mesh application could be very useful.

It is worth noting that Mesh is an independent development to the enhancements introduced by the progression from Bluetooth 4.2 to Bluetooth 5 (longer range and higher throughput).

What is Bluetooth mesh?

A Bluetooth mesh uses the same underlying radio and physical transport as existing Bluetooth low energy. What it adds is a networking layer that allows multiple Bluetooth devices to work together in such a way to enable messages from one device to be sent to another device via one or more intermediate nodes. In other words the network or “mesh” allows two devices to communicate that are too far apart to make a direct point to point Bluetooth connection. In practical terms, a direct point to point Bluetooth connection is limited to around 50m (direct line of sight), or 200m for Bluetooth 5 long range.

In addition to this ability to extend the effective communication distance, the mesh protocol allows devices to be put into groups so that a message can be sent to one device or a group of device.

Bluetooth Mesh example

The above description is a rather dry technical description of what how Bluetooth Mesh allows devices to communicate. Perhaps more illuminating is to give a real world example of how a Bluetooth installation might work.

A Bluetooth Mesh "Smarthome"

In a Bluetooth Mesh Smarthome, the most obvious place to install the core Bluetooth Mesh nodes is in the lighting. So we have all the lights with Bluetooth devices to control whether they are on or off and to dim them if required/capable. In such an installation, lights only have to have access to power (mains, 12V etc, depending on type) – they don't need to be individually wired to switches. This already hugely simplifies the installation of lighting – and makes it more far easier to change in the future.

All the lighting (from a control perspective) is part of a single network. It could be controlled by wall mounted switches (which would also be Bluetooth devices and/or it could be controlled by a Smartphone application, or master controller device application. Switches would not have to be physically connected to anything at all – they would simply transmit their messages (switch on/off light X) to the mesh network, and mesh would take care of the rest. A switch could turn on one light, or many. Or a message could set a lighting "scene" – a set of lights with certain levels of brightness/colour etc.

However, the system wouldn't have to be limited to just controlling the lighting. A thermostat could use the Mesh network to send data to the heating system. A doorbell button could lead to a bell ringing in a distant part of the house. The owner could look up the reading on their electricity meter. Air conditioning, shutters or blinds could be operated.

The big advantage of using Bluetooth technology for these devices is the huge benefit of standardisation. It would not be necessary to design the entire smarthome on day 1; once the basic mesh network is in place, new mesh enabled devices can be added to the network, and controlled via a downloadable smartphone application. So if a Bluetooth mesh enabled heating system was installed later on, the devices could simply join the mesh network. When the network was installed, it would not have to "know" about heating. Commands for heating could pass transparently via the mesh.

A further possibility is that the mesh can track the location of people in the home, and switch on/off devices accordingly; for example, switching off lighting if a room is unoccupied for a certain time. Or the system could connect to some outside data source, so put the heating up ready in the case that a cold spell was forecast.

Of course, the above example could equally apply to an office, or factory.

How does Mesh work in practice ?

The first concept to grasp in the different type of nodes in a mesh network.

Relay nodes

The core network is made up of “relay” nodes. These are nodes that receive and forward messages to other nodes. They can also be connected to a device (i.e. a light, or thermostat etc), and act themselves on a message or generate one. So a relay node receiving a message will look it at, decide if the message is addressed to this node. If it is, it will decode the message and act on it (e.g. switch the light on or off), if it is addressed to a different node, then it will broadcast the message onward.

One important point about relay nodes is that they are not “low-energy nodes”. This might seem strange, given that the underlying protocol is “Bluetooth Low Energy”, so this deserves further explanation.

Bluetooth Low Energy achieves very low power consumption by having the devices “asleep” most of the time. They wake up periodically to send and receive data and then return quickly to their dozy state. In a mesh, the devices have to be ready to transmit and receive data at any time, so they no longer operate on low energy mode. That is why the lighting is the obvious place to locate the core mesh network, as it meets all the requirements, namely: -

- Access to power
- Distance between lights is unlikely to present a range issue
- Suitable for control via the mesh network.

“Friend” nodes

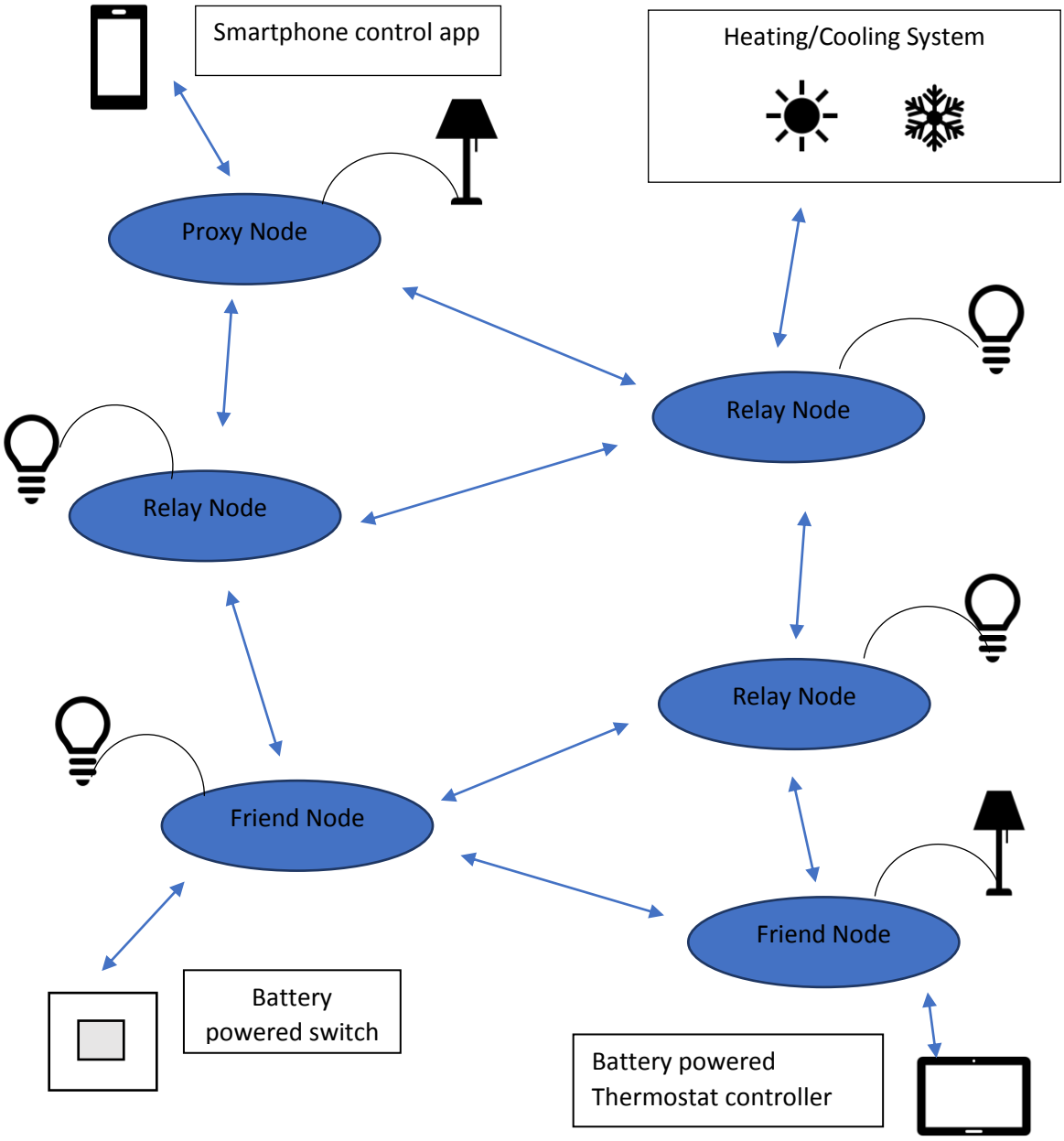
What if you do want to connect a low energy device to a mesh network, such as a battery operated switch ? This is where the concept of a “friend” node comes in. The low energy device is linked to a relay node. The friend device can operate in Low Energy mode, and the associate relay node will store a message, and send it on when the friend node is awake. In the other direction, the friend node sends data when it wants, and the associated relay node is ready and waiting. The main limitation of a friend node is that it cannot act to relay messages in the mesh – in that sense it is an “end point” of the mesh.

Proxy Nodes

I mentioned the ability to control devices via a Smartphone previously. One obvious question is – does my phone, or tablet need to be updated to run mesh ? The answer is no – and this is where a “Proxy node” comes in.

As of today no phones run Bluetooth Mesh. What a Proxy node does is acts as a bridge between a standard BT4+ dual mode device – meaning any Smartphone, tablet or PC that support BLE today – and the mesh. The Proxy node runs both the Mesh and the standard BLE stacks, and can thus receive a message from a phone, and send it on to the Mesh.

A visual representation of this is shown below:



In the above system, the lighting is physically connected to the core relay nodes of the mesh network, and exchanges messages with each other as necessary. Note that the network offers multipath connections – any node can reach any other node via more than one route. So the network does not have single point of failure. If one node fails, the system doesn't fail.

One can control the lighting via battery operated switches – connected via Friend Nodes", or control it via a smartphone application, connecting via a Proxy Node.

The heating can also take advantage of the mesh, connecting a thermostat/controller device, which can communicate to the heating system via the mesh. As stated previously, the connection between

the heating system and thermostat device could have been added long after the basic mesh was installed. There is a process for adding nodes to the mesh, but afterwards, the messages can be transmitted across the mesh without further change to the core network.

Network Protocol

The underlying network protocol for a Mesh is a “limited flooding network”. What does that mean exactly ?

The “flooding” part means that there is no attempt to carrying our routing on the network. Each device transmits to every device that is able to receive it, and those devices transmit onwards to every device they can reach, and so on. Message are given a unique ID, so if a node has already received a message, it doesn’t transmit it a second time (otherwise messages could go round in circles for ever!).

This is as opposed to a network (like for instance an IP based network) which actively route messages to their destination.

The “limited” part is a feature to reduce excessive message forwarding. Each message has a counter to say how many times it has been forwarded, incremented on each forward. It is possible to set a (user defined) limit on the number of “hops” a message makes. The idea being that based on the size of your network, you can limit it to say, four hops, on the basis that if the message hasn’t reached its destination by then, it probably isn’t going to, via this route.

Advantages and Disadvantages

A flooding network has the advantage that it is lightweight (i.e. requires less complex software and therefore a smaller software stack), and is simple to set up and configure. In fact it requires little configuration, and new nodes can be simply added.

The main disadvantage is that it is less efficient for an routed network, in terms of unnecessary messages being transmitted across it.

In use-case terms, if you network is relatively small or has a relatively low rate of message transmission, then this probably won’t matter.

It may lead to some limitations when you have a very large network and you are trying to send a lot of different messages across it at frequent intervals.

Summary

I hope from this article that you can have a better understanding of Bluetooth Mesh and how it works and what it can do. Like any technical solution, it is not the perfect fit for every problem. However, if I were to sum the key advantages they would be

- Automatic cell phone connectivity
- Simplicity in setting up
- Adaptability to change – adding new nodes
- Low cost devices available

The main disadvantage, compared with other solutions would be limitations if a high throughput of messages is required across the network. In many use-cases – e.g home automation, or lighting, this limitation is not a problem.

About the Author

Nick Wood has 25 years of experience in high technology companies, in particular in the Mobile Devices sector. He is a board member of the Innovation Europe investment fund and is part of the Success Europe Investment team and runs his own consulting company, Riviera Associates. Previously, he was a shareholder/director in Teleca Ltd, a UK company specializing in software for advanced mobile handsets, and later Senior Vice President for Teleca AB, a Swedish listed company, responsible for global development of the Mobile Devices Sector. Nick has a 1st Class Degree in Physics from the University of Bristol, and a PhD in Particle Physics gained at University College London and CERN.

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